USE OF GROUND-WATER FLOW MODELS FOR SIMULATION OF WATER-MANAGEMENT SCENARIOS FOR COASTAL GEORGIA AND ADJACENT PARTS OF SOUTH CAROLINA

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REFERENCE: Proceedings of the 2001 Georgia Water Resources Conference, held March 26-27, 2001, at The University of Georgia, Kathryn J. Hatcher, *editor*, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. Ground-water flow models for the coastal area of Georgia and adjacent parts of South Carolina and Florida were utilized by the U.S. Geological Survey (USGS) for simulation of various water-management scenarios. Results of these simulations were used by the Georgia Department of Natural Resources, Environmental Protection Division (GaEPD) to help develop an interim water-management strategy for coastal Georgia. Results of selected model simulations are presented in this paper.

INTRODUCTION

Water supply in the 24-county coastal area of Georgia and adjacent parts of South Carolina and Florida mainly is withdrawn from the Upper Floridan aquifer. Withdrawal of water has resulted in regional ground-water-level decline and local saltwater intrusion in parts of the coastal area. Seawater encroachment on the northern end of Hilton Head Island, S.C., and saltwater intrusion from deeply buried, connate sources at Brunswick, Ga., have been documented.

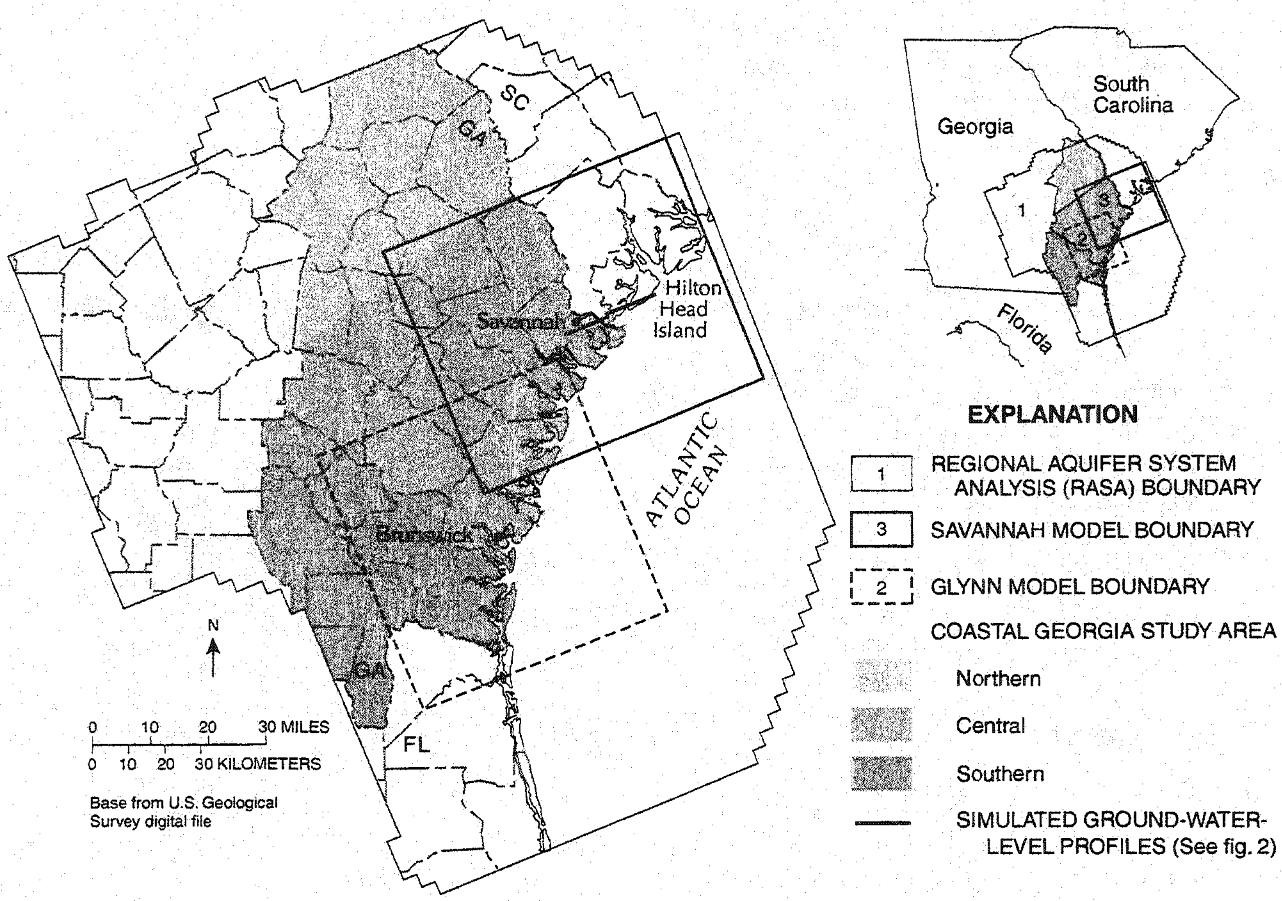

Figure 1. Regional Aquifer-System Analysis (RASA), subregional model boundaries, and coastal Georgia study area (modified from Clarke and Krause, 2000).

Three models, developed as part of regional and areal assessments of ground-water resources in coastal Georgia, were used to simulate water-management scenarios for coastal Georgia: the Regional Aquifer System Analysis (RASA) model, the Glynn County area (Glynn) model, and the Savannah area (Savannah) model (fig. 1). Each model simulates steady-state ground-water flow using the USGS three-dimensional finite-difference MODFLOW code (McDonald and Harbaugh, 1988). Details on model development and calibration are given in Clarke and Krause (2000), Garza and Krause (1996), Randolph and Krause (1990), and Krause and Randolph (1989).

The three models were used to predict effects that hypothetical changes in the distribution and amount of ground-water withdrawal might have on the Floridan aquifer system. The scenarios simulated pumpage changes from 82 million gallons per day (Mgal/d) less to 438 Mgal/d more than the estimated 1985 pumpage (308 Mgal/d).

Results of Water-Management Simulations

The potential for additional withdrawal of from the Upper Floridan aquifer is constrained by water-level declines at locations of saltwater contamination—the northern end of Hilton Head Island and Brunswick. Water-level changes for these areas were simulated to determine if pumpage had any effect on the hydraulic gradient between freshwater and saltwater zones, and the potential for saltwater contamination. Generally, the farther pumping is from the indicator cells at Brunswick and Hilton Head Island, the less is the effect on the ground-water level in the Upper Floridan aquifer and on saltwater contamination.

Effects of pumpage changes on vertical leakage from the Fernandina permeable zone (the source of saltwater) in the area of the Glynn model (fig. 1) also were simulated for each scenario. For scenarios that simulated decreased pumpage, vertical leakage from the Fernandina permeable zone decreased, and water levels at both Hilton Head Island and Brunswick rose, decreasing the hydraulic gradient and potential for saltwater contamination. Conversely, in response to increased pumpage, leakage from the Fernandina permeable zone increased, and water levels at each location declined, increasing the hydraulic gradient and potential for saltwater contamination.

Results from nine scenarios in the Savannah-Hilton Head Island area were used to produce profiles of simulated ground-water levels extending from the point of seawater encroachment on the north end of Hilton Head Island, to the center of the cone of depression at Savannah (fig. 2). These profiles, simulating pumpage reductions in Chatham County of

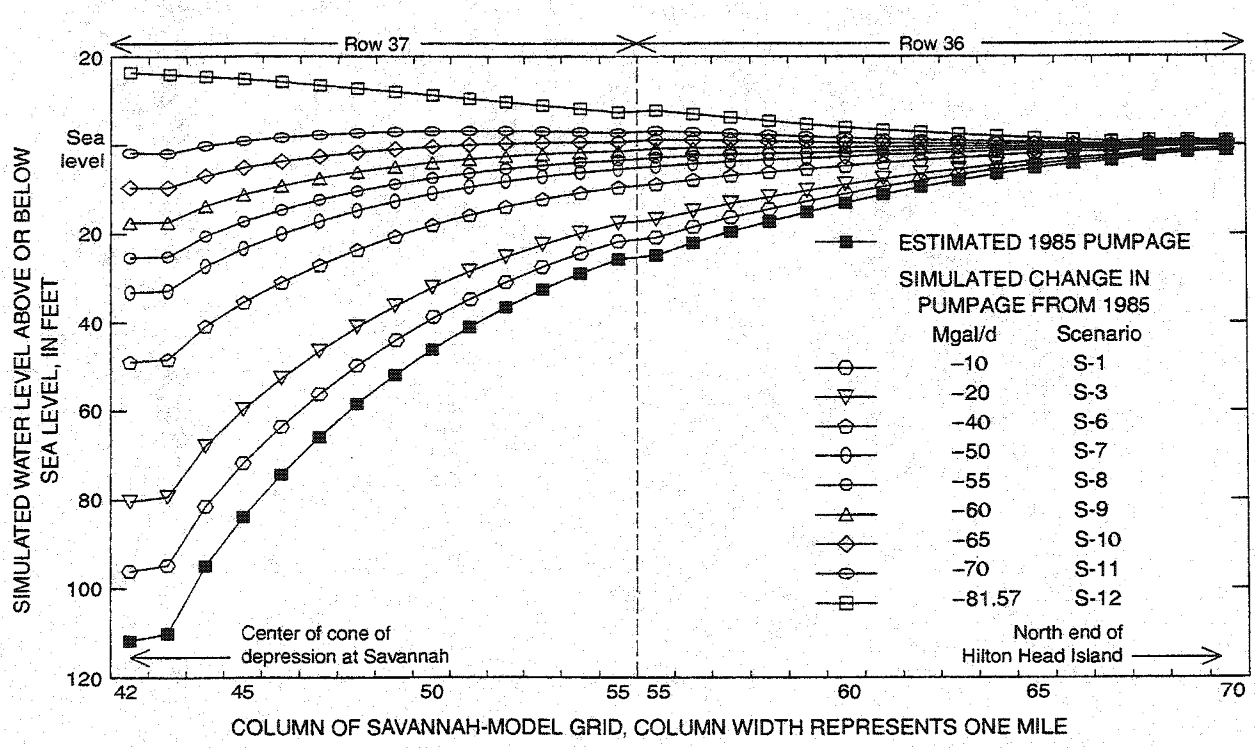

Figure 2. Simulated ground-water-level profiles for the Savannah-Hilton Head Island area for selected water-management scenarios (see figure 1 for location) (modified from Clarke and Krause, 2000).

about 10 to 82 Mgal/d, show the simulated hydraulic gradient toward Savannah is gentler for decreased pumping rates. With reductions in pumpage of 65 Mgal/d or more, the simulated hydraulic profile between Hilton Head Island and Savannah becomes reversed, and has a component of flow in a northeasterly direction from Chatham County toward Hilton Head Island. With cessation of pumpage at Chatham County, the simulated hydraulic gradient along the profile is toward Hilton Head Island and probably is similar to pre-pumping conditions.

Two hydrologic boundaries—the Gulf Trough, separating the northern and central subareas; and the postulated "Satilla Line," separating the central and southern subareas—may affect the development potential of the Upper Floridan aquifer (figs. 3, 4). Model simulations indicate that additional withdrawal may be possible north of the Gulf Trough and south of the "Satilla Line," without producing appreciable drawdown response at Brunswick or Hilton Head Island.

Additional withdrawal may be possible north of the Gulf Trough, as indicated by results from scenario A-4 (fig. 3), which represents a redistribution of pumpage to areas north of the Gulf Trough, and an overall 18 percent increase from the estimated May 1985 rate of withdrawal. Despite this increased pumpage, simulated water levels rose at both Brunswick and Hilton Head Island, and leakage from the Fernandina permeable zone decreased slightly.

South of the hypothesized "Satilla Line," additional withdrawal may be possible, as indicated by results from scenarios G-5 and G-6 (fig. 4), which simulated the effects of a 5 Mgal/d increase in pumpage on the northern and southern sides of the feature. Each scenario resulted in a negligible drawdown response (less than 0.05 ft) at Hilton Head Island. Scenario G-5 resulted in almost twice the drawdown response at Brunswick, as did scenario G-4, suggesting additional withdrawal may be possible south of the Satilla Line without producing an appreciable drawdown response at Brunswick.

Future Studies

Although the three flow models effectively simulate advective ground-water flow, they do not account for effects of variable density and dispersion, and thus

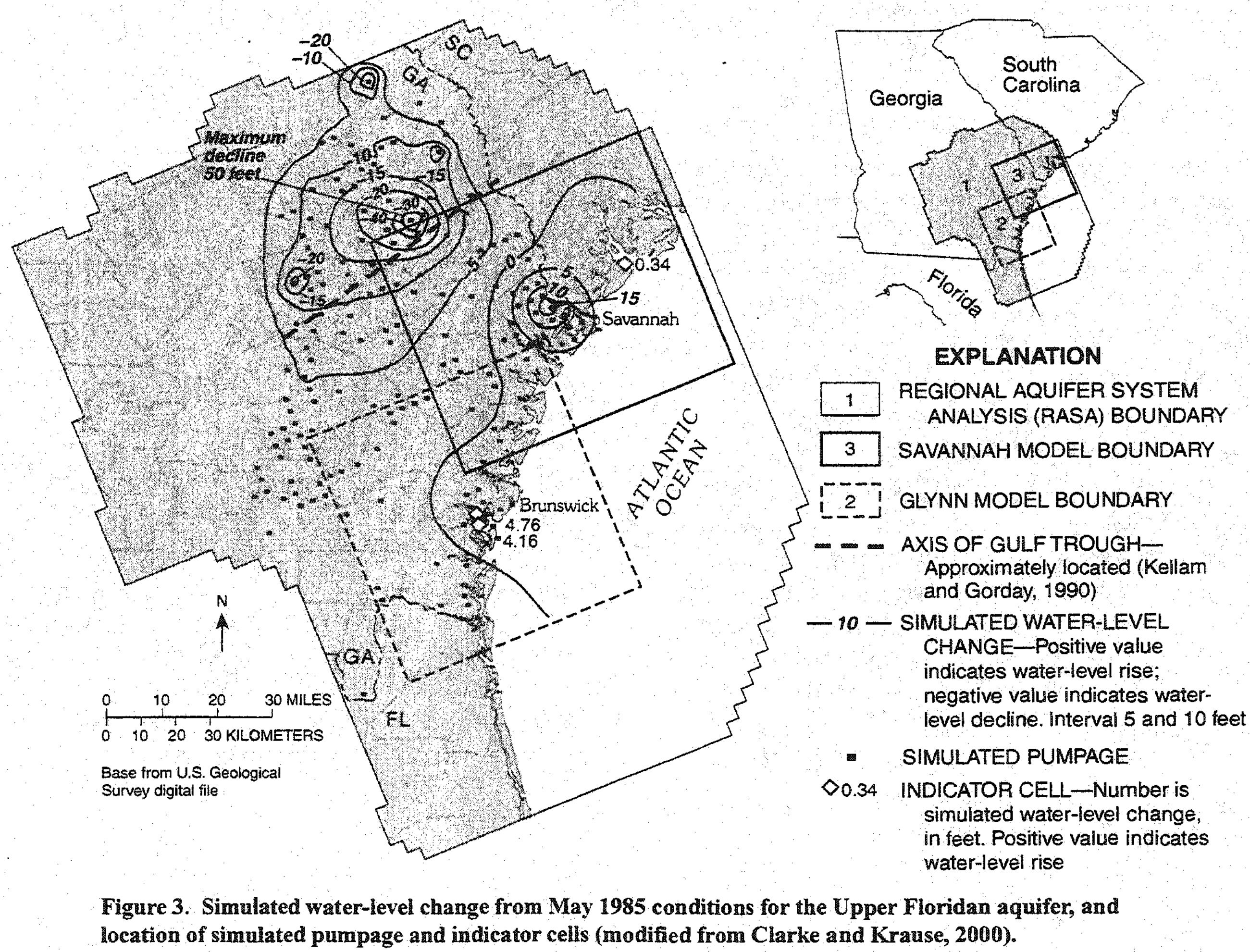

Figure 3. Simulated water-level change from May 1985 conditions for the Upper Floridan aquifer, and location of simulated pumpage and indicator cells (modified from Clarke and Krause, 2000).

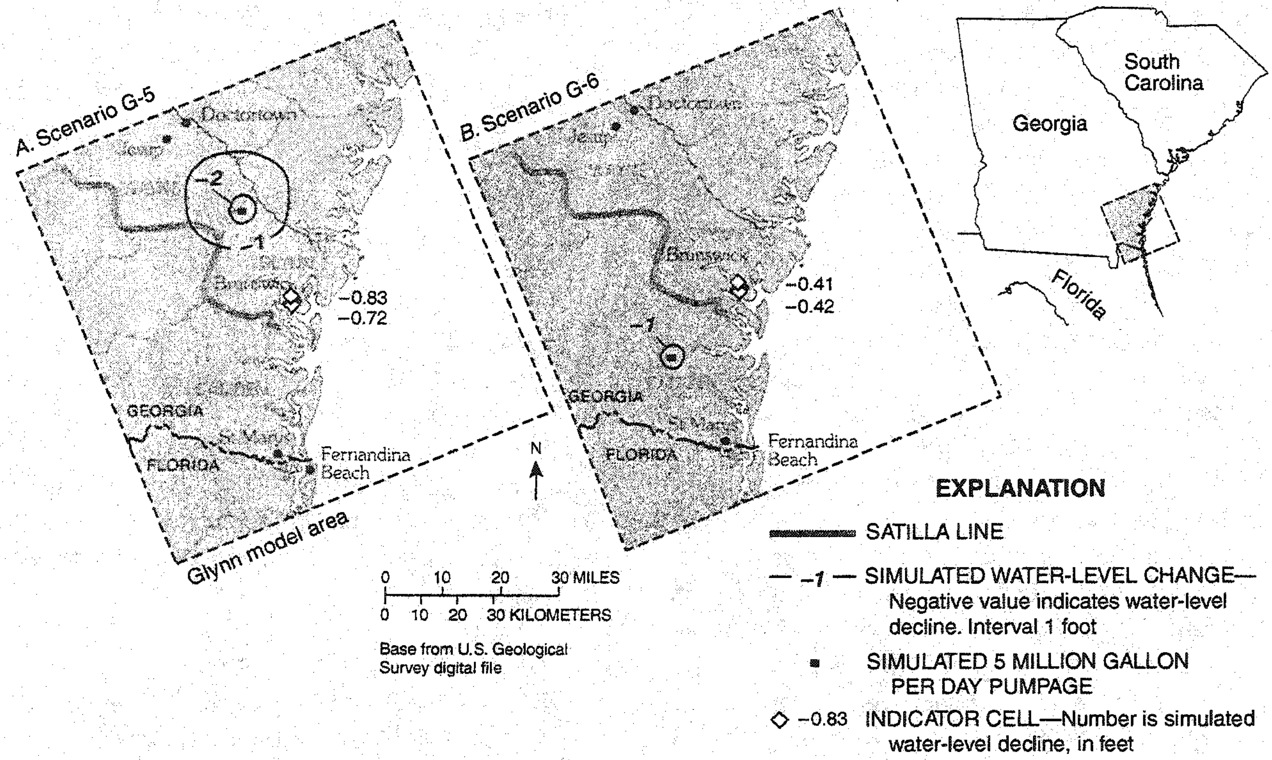

Figure 4. Simulated water-level change from May 1985 conditions for the Upper Floridan aquifer for scenario *(A)* G-5 and *(B)* G-6, and location of simulated pumpage and indicator cells (modified from Clarke and Krause, 2000).

have limited utility to address questions related to seawater encroachment or saltwater intrusion. To better understand and simulate density-dependent flow and solute transport in coastal Georgia, the USGS, in cooperation with the GaEPD, is working on a comprehensive program of data collection and hydrologic simulation (Coastal Sound Science Initiative) that will provide information needed to develop a final water-management strategy for coastal Georgia.

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